

Relationships between Digestive, Circulatory, and Urinary Systems in Portuguese Primary Textbooks

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ABSTRACT In this study, 63 Portuguese primary schoolbooks (1920-2005) were analyzed. The analysis focused on text information (reference to blood absorption and association of the digestive system to other human systems) and on information from images (presence or absence of image “confusion” (when the sequence of the digestive tract is not presented in a clear way, blood absorption representation, and association of the digestive system to other human systems). Results showed that, in general, the text of primary school textbooks (i) refers the nutrients absorption into the blood, (ii) but mentions scarcely the association of the digestive function with the other human functions. The images of the digestive apparatus (i) always present “confusion,” (ii) rarely refer to absorption of nutrients into the blood, and (iii) never associate the digestive apparatus with other human systems. A brief comparison with French textbooks showed that they present more straight representations of the digestive tract sequence (no “confusion”) and generally do not relate it to blood circulation. Since other studies have also showed that French pupils and teachers usually do not draw this “confusion” and do not associate the digestion process to blood absorption, our results suggest that inadequate images of textbooks may be didactical obstacles to accurate learning.

Key-words: Biology education, learning obstacles, primary school, textbook analysis.

Introduction

Portuguese primary school pupils (Carvalho, Silva, & Clément 2003; Carvalho, Dantas, & Clément, 2004) as well as pre-service and in-service primary school teachers (Carvalho et al. 2004) show difficulties (i) in representing a clear sequence of the digestive track (they draw “confusion”), (ii) in referring to the blood absorption, (iii) and in making the relationship between digestive, circulatory, and urinary systems. In contrast, French similar samples do not show this “confusion,” but, like the Portuguese ones, they do not associate the digestion process with blood absorption and other human systems (Clément 2003a, 2003b).

In the decade of the 80s, French Biology Education researchers (Clément, Serverin, & Luciani 1981; Giordan & de Vecchi 1987; Clément, 1991) indicated that the permeability of the intestinal wall is an important epistemological obstacle related to the digestion. During everyday life, tubes are generally seen as having impermeable walls, which originates an obstacle to the understanding of the permeability of the body tubes (intestine, blood capillaries, kidney nephron tubes, etc). As a consequence of this epistemological obstacle, most children and adults

draw a continuous path between their intestine and their bladder, when they are asked to represent the water pathway in their body, immediately after drinking water. French school textbooks do not help students to overcome this obstacle as images generally represent the pathway of non digested food, from the mouth to the anus, missing the absorption process to the blood. Only recently, some French textbooks, using results of Biology Education research, started to change their images in order to associate the digestion process with the circulatory system.

Therefore, it was not surprising to find this epistemological obstacle in Portuguese pupils', students' and teachers' conceptions, as well as in school textbooks (Clément 2003a; Carvalho *et al.* 2004). It was however surprising that the great majority of Portuguese teachers, when asked to draw their digestive tract (or the pathway of water or food in their body), they do not draw a continuous tube from the stomach to the anus, but a complex mass of organs that we labelled "confusion," without an evident anatomy of a digestive track. In contrast, this "confusion" was absent, or exceptional, in France, as well as in Great Britain (Clément & Tunnicliffe 2002), and in Tunisia (Kammoum, Chapron, & Clément, 2002).

An initial rapid comparison between current French and Portuguese primary school textbooks showed that most of the images of a digestive system show this "confusion" in the Portuguese, but not in French textbooks. We were therefore interested in analysing the digestion topic in primary school textbooks since the beginning of the 20th century in an attempt to find out the origin of this Portuguese specificity and to compare with French textbooks. Major attention was given to the presence or absence of "confusion" representation and to the association of digestion with blood absorption, and the relationship of the digestive system to other systems.

Methodology

The list of analysed school textbooks is shown in Appendix I, and T in the text is used for Textbook identification that is accompanied with its respective number. The criterion for textbook selection was to use mostly those used in the Northern region of Portugal, where previous studies on pupil's and teachers' conceptions had been carried out (Carvalho, Silva & Clément 2003; Carvalho *et al.* 2004; Carvalho, Dantas & Clément 2004).

Grids to analyse the school textbooks were prepared as follows:

1. General
 - 1.1. Black and white or Colour (B & W / C)
 - 1.2. Proportion of the digestion pages of all human systems pages (%)
 - 1.3. Proportion of the space occupied by images in relation to text (%)
 - 1.4. Presence or absence of relationship between the digestion system and the other human systems (Yes/No)
2. Images
 - 2.1 Image captions (Yes/No)
 - 2.2. Image giving scientific information (Yes/No)
 - 2.3. Image with scientific errors (Yes/No)
 - 2.4. Image showing "confusion" (Yes/No)

2.5. Image referring to “absorption” (Yes/No)

3. Text

3.1. Text giving scientific information (Yes/No)

3.2. Text with scientific errors (Yes/No)

3.3. Anatomy and/or Physiology text emphasis (An/Ph)

3.4. Text mentioning “absorption” or “pass to the blood” (Yes/No)

4. Practical activities

4.1. Experimental activities (Yes/No)

4.2. Exercises to consolidate acquired knowledge

In the present work, special emphasis was given to the “presence or absence of relationship between the digestion system and the other human systems” (Item 1.4), “images showing ‘confusion’” (Item 2.4), “images referring ‘absorption’” (Item 2.5) and “text mentioning ‘absorption’ or ‘pass to the blood’” (Item 3.4).

Analysis of Portuguese Primary School Textbooks

Preliminary Textbook Analysis: 2001-2003

The preliminary study for general comparative analysis of 10 textbooks (2001-2003) is shown in Table 1. Of the 5 human systems that are required to be taught by the National Programme (Digestive, Respiratory, Circulatory, Urinary, and Reproductive systems), the digestive one corresponded to about 20%, except in T2 and T10, with lower proportions of 12% and 6%, respectively.

Table 1
Preliminary Analysis of Primary School Textbooks: 2001-2003

	Edições Nova Gaia		Galilivro			Livraria Arnado		Porto Editora		
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Dig/others ¹	20%	12%	27%	33%	25%	17%	17%	17%	17%	6%
Ima/text ²	25%	25%	25%	33%	25%	25%	25%	33%	33%	12%
Images ³								a)		
- captions	Yes	Yes	No	Yes	Yes	Yes	Yes	---	Yes	No
- confusion	Yes	+/-	No	Yes*	Yes	Yes*	Yes	---	Yes	Yes
- absorption	No	No	No	No	No	No	No	---	No	No
- other syst.	No	No	No	No	No	No	No	---	No	No
Text ⁴										
- An / Ph	An	An	An+Ph	An+Ph	An+Ph	An+Ph	An	An	An	An
- absorption	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
- other syst.	No	No	No	No	No	No	No	No	No	No

Dig/others¹ - Proportion of digestive system to other human system.

Ima/text² - Proportion between the space occupied by images and texts in the digestive system topic.

Images³ - The image message: captions present or not, clear or confused sequence of the digestive tract, indication/reference to blood absorption and or other human systems.

Text⁴ - Text contents: anatomy (An) and/or physiology (Ph), reference to blood absorption and other human systems.

a) No biological structure represented, just a dressed up girl.

* See Fig.1

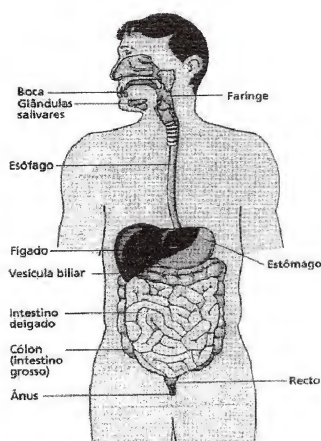


Figure 1. Example of “Confusion” (2001 – T4).

With the exception of T10, images occupied about 25% of the total space dedicated to the digestive system (Table 1). Most of the images (8 of 10 textbooks) represented a mass of small intestine with no evident connection with the stomach and the large intestine. Therefore, no clear sequence of the digestive track could be seen, as shown in the example of Figure 1. We named this kind of unclear sequence of the digestive tract “confusion.”

Although these textbook images never represent blood absorption, most of the texts mention absorption, as the following examples of the same T4 and T6 textbooks show:

T4: *“In the small intestine, food is reduced into very small substances, due to bile action, pancreatic juices, and also its movements. Some of these substances pass to the blood.”*

T6: *“The small intestine is a very long tube, where the useful substances to the body pass to the blood.”*

Six of the textbooks analysed (T1, T2, T7, T8, T9, and T10) described only the morphology of the digestive tract, whereas four (T3, T4, T5, and T6) refer to the physiology of digestion, albeit in a very simple way. In addition, no association of digestion to other human systems was found in any textbook, either by images or text. In fact, each topic is included in a different chapter of the textbook.

Analysis of Primary School Textbooks: 1920 – 2005

This preliminary study of 10 textbooks indicated that most images (8 out of 10) presented “confusion” and neither represented blood absorption, nor made association to other human systems. Thus, it was decided to analyse earlier school textbooks (since 1920) in order to understand the evolution of digestion images in textbooks and to examine whether this current (2001 – 2003) type of image is traditional in Portuguese primary school textbooks. The textbooks were organised in groups by publishers, and within each publisher by chronological order. It was thus possible to compare books from the same Publisher, but it was not possible to keep an exact chronological order. Two main periods were considered, namely, the first between 1920 and 1959 (before the reform of the National Education System) and the second between 1960 and 2005 (after the reform).

Results show that the proportion of the digestive system in relation to all human systems was slightly higher in earlier textbooks (30% and 25%, for 1920-1950 and 1960-2005, respectively), but no other substantive differences could be identified. Similarly, no substantive differences were found between image/text ratios, as it varied during the whole period between 1/2 and 1/10, with a mode of 1/4. In the whole period, there was a clear progress in terms of design and drawing aesthetics, as well as the introduction of a few colours (in the early 60’s) and more colours later.

Each book was analysed in terms of *image* representation by observing: (i) the

presence or absence of image “confusion,” (ii) blood absorption representation, and (iii) association of the digestive system to other human systems. Similarly, the *text* was analysed for explicit words referring (i) to blood absorption and (ii) association of the digestive system to other human systems. Table 2 summarises the results of images and text analysis in both periods (1920–1959 and 1960–2005), concerning “confusion,” absorption, and relationship between the digestive system and other human systems.

Table 2.
Images and Text Analysis of the Digestion Topic in Textbooks
of Two Periods (1920 – 1950 and 1960 – 2005)

	1920 -1950	1960 -2005
IMAGE ANALYSIS		
“Confusion”	11/11 (100%)	37/52 (71%)
Absorption	0/11 (0%)	3/52 (6%)
Association to other human systems	0/11 (0%)	0/52 (0%)
TEXT ANALYSIS		
Absorption	10/11 (91%)	50/52 (96%)
Association to other human systems	3/11 (27%)	7/52 (13%)

Results in Table 2 indicate that “confusion” was found in all *images* of 1920-1950 textbooks. In contrast, the *text* of 10 out of 11 (91%) textbooks mentioned the absorption process. The first images showing no “confusion” were found in 1961 (M12). However, at this period, some Publishers could present “confusion” in some textbooks, but not in other ones. After 1960, “confusion” was present in 71% of the textbooks (37 in 52), but it was not possible to perceive any kind of chronological evolution or tendency in the representation of the digestive tract, as far as this “confusion” in images was concerned.

The absorption process representation was absent in all (100%) textbooks *images* before 1960, and present in only 3 out of 52 (6%) of the books after 1960 (M51, M57 and M59). In contrast, the *text* of most books made reference to the absorption process to the blood. Thus, 10 out 11 textbooks before 1950 and 50 out of the 52 textbooks after 1960 had explicit reference to the absorption process

The results in Table 2 also indicate that *images* never (0%) made any association between the digestive tract and the other human systems in textbooks, either before or after 1960. However, in both periods, there were few textbooks (3 out of 11 before 1960, and 7 out of 52 after 1960) that made reference in the *text* to the relationship of the digestive system with other human systems. This relationship was however more frequent in the earlier books (27% before 1960) than in the most recent ones (13% after 1960). More detailed analysis of the textbooks after 1960 indicates that this relationship appeared in three books in the 60s (M13, M15, and M16), in one book in the 70s (M21), in two books in the 80s (M23 and M27), and in one book in the early 90s (M32). After 1993, no relationship between the digestive system and the other human systems could be found, neither in the text nor in images.

Altogether these results indicate that the decade of the 1960s was the period

where textbooks had higher pedagogical value, as they showed lower frequency of digestive tract *image* “confusion,” and higher frequency on *text* explicit reference to the interrelationship between the digestive tract and other human systems.

Comparison between Portuguese and French Primary Schooltextbooks

The results concerning the period 1926-1960 clearly confirm the hypothesis that there is no evolution in the contents and images of Portuguese primary school textbooks during this period. In particular, all images of the digestive tract are represented in the way we labelled “confusion” between the stomach and the anus. In contrast, the images of the digestive apparatus clearly developed in the French primary school textbooks during the same period (Perrier & Clément, 1997). At the beginning of the 20th century, all digestion images of French textbooks presented “confusion,” with images of open abdomen. However, still during the first half of the 20th century, these images became simplified and tend to clearly show the continuity of the intestine from the stomach to the anus. This evolution is probably associated with the pedagogical renewal in the republican schools, including the dynamics initiated by Wallon, and also by Freinet and his movement of active pedagogy. As a consequence, the image of “confusion” progressively disappeared in the French textbooks, and, consequently, from the conceptions of students and teachers (Clément *et al.* 1981, Clément 1991, 2001, 2003b) as well.

Deriving from medical anatomical images, the figure “confusion” progressively disappeared in French textbooks, and was replaced by more pedagogical images clearly showing the continuity of the intestine. But, they did not disappear in Portugal, where movements for an active and renewed pedagogy did not occur during this period of dictatorship.

The Stability of the Traditional Portuguese “Confusion” Representation

Before 1960, all Portuguese drawings were showing the “confusion” images, whereas after 1960, the confusion was reduced to 71%, as it is indicated in Table 2. The other textbooks drew the digestive tract similar to the French textbooks, as it is indicated in Figure 2.

The reduction of the frequency of drawing “confusion” in the Portuguese textbooks happened timidly in the decade of the 1960’s, but afterwards it regressed to the traditional “confusion” style.

Concerning the epistemological obstacle of the permeability of the intestine wall (and of the capillaries), the initial French research was conducted within a university context (Clément *et al.* 1981, Clément 1991), but only recently the French syllabuses and textbooks changed, introducing more clearly links between digestion and circulation, as it can be seen in Figure 2. The most recent French syllabus of fifth grade (students 12-13 years old) start from the muscular effort topic, referring to the requirement of energy coming from the circulatory apparatus, and proceed to explain that food and

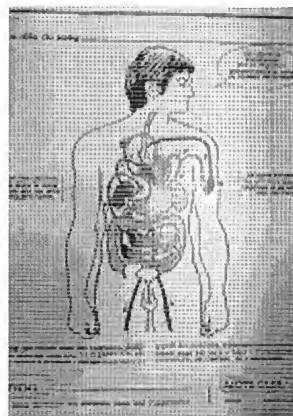


Figure 2. Example of a Clear Image (no “confusion”), Showing Relationship with the Blood System in a French Textbook (Mangnard 1993).

energy are provided by digestion.

Even in the primary school textbooks, the absorption process has been more and more well illustrated (e.g., in the French Hachette textbook of 1997) and arrows, in both drawings and flow diagrams, indicate the blood capillaries. Some French primary school textbooks (e.g., Magnard 1993, Figure 2), but none of the Portuguese ones analysed in this study present images representing the association between the digestive system and the other human systems, such as, the circulatory and the urinary ones. The present study clearly indicates that these associations are never present in the Portuguese primary school textbooks that were analysed.

ACKNOWLEDGEMENTS

This work had the financial support of the Portuguese institution Fundação para a Ciência e a Tecnologia (FCT-POCTI/CED/44187/2002) as well as the European project FP6 Biohead-Citizen CIT2-CT-2004-506015.

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Appendix I - School textbooks

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- [T4] Freitas, M. (2001) *Pequeno Mestre*. Vila Nova de Gaia: Gailivro.
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